Unification of Weak and Gravitational Interactions Stemming from Expansive Nondecelerative Universe Model

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Abstract. There is a deep interrelationship of the General Theory of Relativity and weak interactions in the model of Expansive Nondecelerative Universe. This fact allows an independent determination of the mass of vector bosons Z and W, as well as the time of separation of electromagnetic and weak interactions.

In the early stage of the Universe creation, i.e. in the lepton era an equilibrium of protons and neutrons formation existed at the temperature about 10^9 - 10^{10} K which corresponds to the energy of 1 MeV (a lower side of the range of weak interaction energies). The amount of neutrons was stabilized by processes including antineutrinos (eq.1) or neutrinos (eq.2) such as

$$\nu + p^+ \rightarrow n + e^+ \quad (1)$$

$$e^- + p^+ \rightarrow n + \nu \quad (2)$$

The cross section σrelated to the above processes can be expressed [1, 2] as

$$\sigma \cong \frac{g_F^2 . E_w^2}{(\hbar . c)^4} \quad (3)$$

where g_F is the Fermi constant (10^{-62} J.m^3), $E_w$is the energy of weak interactions that, based on (3), can be formulated by relation

$$E_w \cong \frac{r.\hbar^2 . c^2}{g_F} \quad (4)$$

where r represents the effective range of weak interactions. Stemming from relation (4) it holds that in limiting case when

$$r = \frac{\hbar}{m_{ZW} . c} \quad (5)$$

the maximum energy of weak interaction is given by

$$E_w \cong m_{ZW} . c^2 \quad (6)$$

Relations (5) and (6) represent the Compton wavelength of the vector bosons Z and W, and their energy, respectively. Equations (4), (5) and (6) lead to expression for the mass of the bosons Z and W

$$m_{ZW}^2 \cong \frac{\hbar^3}{g_F . c} \cong |100 GeV|^2 \quad (7)$$

providing the value that is in good agreement with the known actual value.

For the density of gravitational energy ε_g it follows from the ENU model [3 - 5]

$$\epsilon_g = -\frac{R.c^4}{8\pi . G} = -\frac{3m.c^2}{4\pi . a . r^2} \quad (8)$$

where ε_g is the gravitational energy density of a body with the mass m in the distance r, R is the vector curvature, a is the gauge factor that reaches at present

$$a \cong 10^{26} m \quad (9)$$

As a starting point for unifying the gravitational and weak interactions, the conditions in which the weak interaction energy E_w and the gravitational energy $E_g$of a hypothetic black hole are of identical value

$$E_w = |E_g| \qquad (10)$$

can be chosen. Based on relations (4), (8) and (10) in such a case it holds

$$\frac{r.\hbar^2.c^2}{g_F} = \left|\int \epsilon_g dV\right| \approx \frac{m_{BH}.c^2.r}{a} \qquad (11)$$

where m_{BH} is the mass of a black hole and r is the range of weak interaction. It follows from (11) that

$$m_{BH} \cong \frac{a.\hbar^2}{g_F} \qquad (12)$$

The above relation manifests that the mass of a black hole depends on the gauge factor, i.e. it is increasing with time. On the other hand, the black hole mass may not be lower than the Planck mass m_{Pc}

$$m_{BH} \geq m_{Pc} \qquad (13)$$

that approximates

$$m_{Pc} = \left(\frac{\hbar.c}{G}\right)^{1/2} \cong 10^{19} GeV \qquad (14)$$

The gravitational radius l_{Pc} of a black hole having the minimum mass m_{Pc} is

$$l_{Pc} = \left(\frac{G.\hbar}{c^3}\right)^{1/2} \cong 10^{-35} m \qquad (15)$$

If there is a mutual relationship of the gravitational and weak interactions, there had to be a time t_x corresponding to a gauge factor a_x when m_{BH} and m_{Pc} were of identical value. It was the time of weak interactions formation. In such a case it stems from (12) and (13) that

$$a_x \cong \frac{m_{Pc}.g_F}{\hbar^2} \cong 10^{-2} m \qquad (16)$$

and

$$t_x \cong 10^{-10} s \qquad (17)$$

This is actually the time when, in accordance with the current knowledge, electromagnetic and weak interactions were separated (it might be worth mentioning that its value represents also typical duration of weak interaction processes). In the time t_x it had to hold

$$\frac{m_{Pc}}{m_{ZW}} = \left(\frac{a_x}{l_{Pc}}\right)^{1/2} \qquad (18)$$

Substitution of (16) into (18) leads to (7) which means that the mass of the vector bosons Z and W as well as the time of separation of the electromagnetic and weak interactions are directly obtained, based on the ENU model, in an independent way.

Conclusions:

1.The Vaidya metrics [6] based ENU model allowing to localize the gravitational energy exhibits its capability to manifest some common features of the gravitational and weak interactions.

2.The paper presents an independent mode of determination of the mass of vector bosons Z and W, as well as the time of separation of the electromagnetic and weak interactions.

3.The paper follows up our previous contributions showing the unity of the fundamental physical interactions.

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